

# THE INFLUENCE OF COD LIVER OIL ON TUBERCULOSIS

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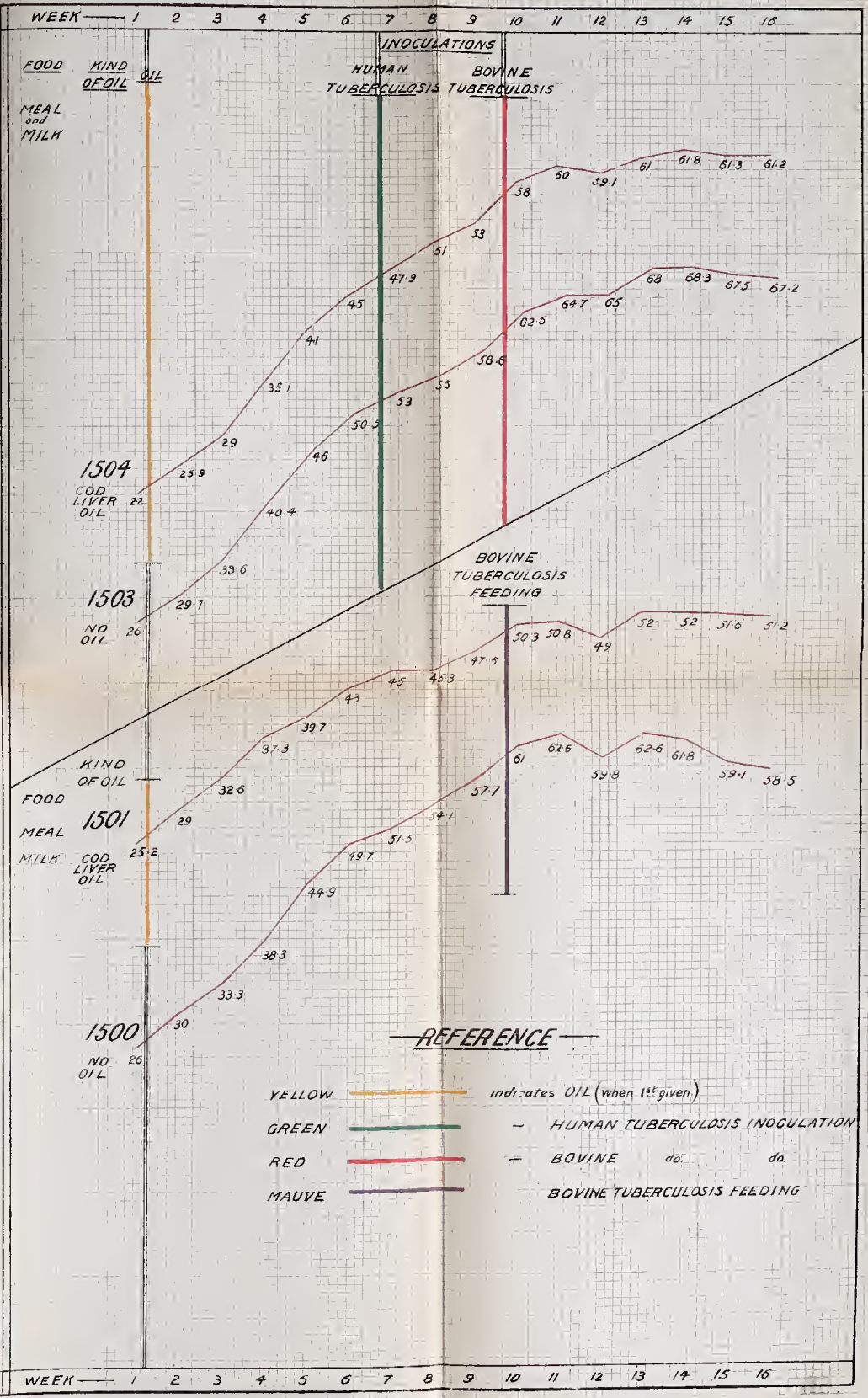
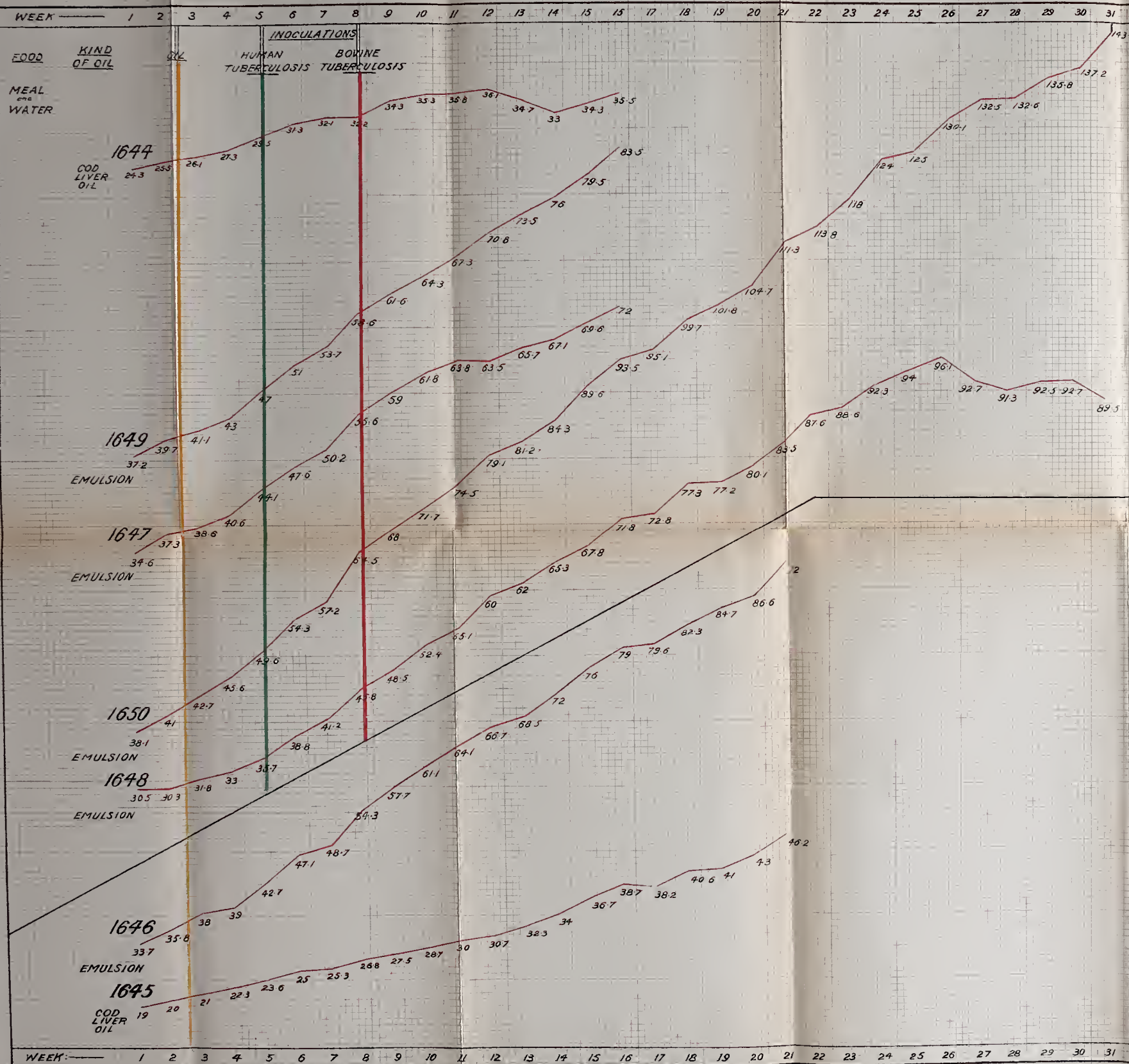
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A Comparative Study of the  
influence of Cod-liver Oil,  
and Cod-liver Oil Emulsion,  
upon the Nutrition of Normal  
and Tuberculous Pigs.

BY

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## PREFACE.

IN the following pages the writer has marshalled together some experimental results, with the hope that the reader may estimate the comparative values of Cod-liver Oil and Cod-liver Oil Emulsion, with the addition of Glycerine and Hypophosphites, on normal and Tuberculous pigs.

The experiments recorded in this paper were conducted in the Public Health Laboratory of the University of Manchester, under the supervision of Professor Sheridan Delépine.

J.W.W.

*March 1, 1907.*



## CONTENTS.

	Page
INTRODUCTION - - - - -	9
OBJECTS OF THE INVESTIGATION - - -	13
THE ANIMALS USED - - - - -	21
RECORD OF RESULTS OF THE EXPERIMENTS - -	33





## Introduction.



FATTY Foods, and more particularly Cod-liver Oil, have taken a leading place among the foods and drugs used in the treatment of tuberculosis, and more especially of pulmonary consumption.

It is not difficult to substantiate this statement.

Theodore Williams, in a brief article upon phthisis, sums up the ideas which have been prevalent during the last fifty years in the following words:—

“Fatty material, if it can be digested, should be largely represented in the dietary, and many physicians advise large quantities of cream,

## 10 INFLUENCE OF COD-LIVER OIL

butter and such; but, considering the large amount of fatty matter included in Cod-liver Oil, which is a severe test at first to the digestive powers, it is not advisable to increase the amount of fat until the oil is well tolerated."

Elsewhere the same author says:—

" . . . . Cod-liver Oil . . . . has been shown to be the most effective agent of all in improving nutrition and rendering the individual less liable to bacillar attack. . . . . Other oils are of use, but few equal the Cod-liver Oil in efficacy, on account of its great penetrating power, and of its forming with the biliary and pancreatic juices a compound easily absorbed by the lacteals." (Art. Phthisis, "Quain's Dictionary," 1895, ii., p. 416.)

The late Sir John Syer Bristowe, nearly thirty years ago, expressed similar views:—

" . . . . There is one article—drug or food—namely, Cod-liver Oil, which during the last thirty years has acquired a special reputation. There is little doubt on the part of the practical physician, none on the part of the public, of the great value of this in the treatment of phthisical and scrofulous patients. . . . . It is now largely believed that the virtues of Cod-

liver Oil depend chiefly upon the fatty matter of which it mainly consists; and since it has been assumed that *other fats might prove equally beneficial*, the use of cream, neat's foot oil, olive oil, and other vegetable and animal fats, and of glycerine, has consequently been recommended." (J. S. Bristowe, "A Treatise on the Theory and Practice of Medicine," 2nd Ed., 1878, p. 446.)

The doubts alluded to by the last writer as to the specific value of Cod-liver Oil have become more pronounced in latter years, and many physicians have ceased to look upon Cod-liver Oil as a drug, though they still regard it as a most useful fatty food.

Thus Dr. Percy Kidd says:—

"Cod-liver Oil is a valuable adjunct to the diet, but is possessed of no specific virtues. This valuable food is sometimes prescribed in a manner to bring it into discredit, that is, when it is administered in too large quantities. . . . Many patients prefer to take it in the form of an emulsion, or in combination with malt extract." (Percy Kidd, in T. Clifford Allbutt's "System of Medicine," 1898, Vol. v., p. 231.)

Sir Thomas Lauder Brunton attributes the value of Cod-liver Oil to it being readily assimil-

## 12 INFLUENCE OF COD-LIVER OIL

able, which he expresses tersely in the following passage :—

“Cod-liver Oil is rather a food than a medicine, and its therapeutic use depends on two properties, viz., its ready absorption and its ready assimilation.” (T. Lauder Brunton, “Pharmacology, Therapeutics and Materia Medica,” 3rd Edit., 1887, p. 1087.)

There is nothing in the composition of Cod-liver Oil which would allow of any *a priori* opinion being formed.

At the beginning of the nineteenth century Cod-liver Oil had fallen into disuse in this country as a medicine, and was again brought into public notice by Dr. Hughes Bennett, of Edinburgh, in 1841, since which time its use has advanced rapidly.

The great bulk of the Cod-liver Oil consumed at the present time has undergone some pharmaceutical method of preparation.

It is not necessary to multiply references in order to show that two views have been held regarding the use of Cod-liver Oil in the treatment of tuberculosis; some physicians look upon the oil as being both food and drug, others regard it as merely an easily assimilable fat, to which other fats may be substituted. Among the substitutes which have been proposed the following may be



mentioned:—Milk, cream, butter, suet, olive oil, liquid paraffin or petroleum oil, sesame oil.

Notwithstanding differences of opinion, Cod-liver Oil and Emulsion of Cod-liver Oil continue to be extensively used in the treatment of chronic tuberculous affections.

### **Objects of this investigation.**

It appeared to the writer desirable to ascertain if possible whether the actual value of Cod-liver Oil and of Cod-liver Oil Emulsion could be tested experimentally. Previous experiments with various drugs did not encourage the hope that any very great effect could be produced upon the tubercle bacillus after it had penetrated into the tissues. On the other hand, there was sufficient evidence to show that when in suitable condition the living tissues were capable of offering considerable resistance to invasion. Anything tending to improve the general health of the patient would tend to increase the chances of the organism in its struggle with the bacillus. A good state of nutrition was obviously one of the most important factors in the maintenance of health. It would therefore be useful to know how the administration of the substances to be tested would affect the growth and general health of tuberculous animals.

In 1904 I had the privilege of discussing the

## 14 INFLUENCE OF COD-LIVER OIL

matter with Professor Delépine, the Director of the Public Health Laboratory, University of Manchester, and on his advice the following scheme of experiments was decided upon. Pigs appeared to be the most suitable for the experiments, since they are animals capable of thriving on diets suitable for human beings and of taking readily Cod-liver Oil and Cod-liver Oil Emulsion.

The pigs were young, actively growing, of the same breed, of the same age, and as far as possible of the same weight. They were kept in sties of the same type, same size, exposed to exactly similar external conditions.

Each animal was fed regularly. All the animals used in one set of experiments received the same kind of food, given in quantities bearing the same proportion to the body weight in all cases.

After keeping these animals under observation some time in order to ascertain that they were all healthy and thriving, the substances tested were administered to the various pigs in doses calculated weekly, giving the same proportionate amount of oil per pound weight of the pig as that given to a man of average weight as a suitable dose. Pigs which served as controls received the same food as the others, but no oil.

After ascertaining that the pigs were able to take the dose of oil given to them they were all

rendered tuberculous, either by ingestion of bovine tuberculous organs, or by inoculation of cultures of bovine and human tubercle bacilli.

Each pig was kept under observation for several months; some were killed at the end of four months to ascertain the state of comparatively early lesions; others were kept for seven or eight months for the study of later changes. During the whole time the animals were kept under close observation, and their weight was taken at regular intervals of two or three days, at the same time of the day, before meals. In all cases the pigs were killed before the disease had reached such a stage as to cause pain.

A careful examination was made of each pig immediately after its death. The nature and duration of these experiments made it impossible to carry them out except in a well-equipped laboratory; and I therefore arranged that the work should be done under Professor Delépine's direction in the Public Health Laboratory of the University of Manchester. All the inoculations were made by him.

The writer decided, in the first instance, that Cod-liver Oil and a Cod-liver Oil Emulsion should be tested, because—

- (1) They have been largely used in the treatment of tuberculosis.

## 16 INFLUENCE OF COD-LIVER OIL

- (2) It was not possible, for reasons of time and expense, to experiment with every variety of oil and emulsion which had been used in the treatment of tuberculosis.
- (3) It would demonstrate the effect of emulsification together with the effect of the addition of glycerine, hypophosphites, etc.

### **Cod Liver Oil.**

Cod-liver Oil is a remedy of great antiquity, and is said to have been used by the Greenlanders, Laplanders and Esquimaux before they came in touch with civilisation.

The oil used by these primitive people was doubtless a very crude product, and various improvements in the preparation of the oil have been made since these early days.

The oil is extracted from the livers of the various Gadidæ, although differences exist in the oil expressed from the livers of fish in the various fisheries, probably due to the care in selection of the cod and rejection of other species, and also to the special environment, such as temperature, depth of water and food supply, which can be observed in the differences between Norwegian and Newfoundland Cod-liver Oil.

The variety selected was that known as *Pale Norwegian Cod-liver Oil*, which is a product that

varies very greatly in quality according to its method of preparation. The higher qualities of Pale Norwegian Oil (Lofotin) are fairly constant in composition. The glycerides of this oil have a high iodine value, showing that they are not wholly composed of palmitin and stearin. The unsaponifiable matter is largely composed of cholesterol, an unsaturated alcohol occurring very widely disseminated in the animal kingdom. Poor oils contain some nitrogenous compounds, but the oil used—viz., a Pale Norwegian (Lofotin) obtained from Messrs. Scott and Bowne—contained only 0·01 per cent. of nitrogen. The iodine contained in Cod-liver Oil is also very small, and may be taken as about 0·02 per cent. of iodine chemically combined as a complicated organic compound.

As Scott's Emulsion of Cod-liver Oil was used in the experiments, it was desirable to obtain exactly the same oil as formed part of that preparation in order that any differences between the plain oil and the emulsion might be made manifest.

The rancidity of Cod-liver Oil is very largely due to the formation of hydroxy fats and to the splitting up of the oil into free fatty acid and glycerine. The pale oils are almost odourless, more palatable and better tolerated by the stomach than the darker oils. A well-prepared oil may



## 18 INFLUENCE OF COD-LIVER OIL

be kept for years with little or no alteration. Pure Cod-liver Oil has a very low acetyl value, the oil used having value of about 20, showing the comparative absence of hydroxy fats. Some dark oils examined had acetyl values of about 90.

### **Cod Liver Oil Emulsion.**

The emulsion selected was that known as "Scott's Emulsion," of which the most important ingredients are according to published formula :

Pure Norwegian Cod-liver Oil ...	44%
Glycerine ... ..	16%
Hypophosphite of lime... ..	1.25%
Hypophosphite of soda ... ..	0.625%

Emulsion cannot be strictly compared to Cod-liver Oil because it contains in addition glycerine and hypophosphites, but the amount of oil given to the pigs was the same.

Henry Loffman, M.D., and William Beam, M.D., of Philadelphia (Ex. "Medical News," May 21st, 1892, Vol. 577), state that the excellence of an Emulsion of Cod-liver Oil depends upon the proportion of oil present, and upon the perfection of emulsification.

The per cent. of oil present varied from zero to 49.9 in the specimens they examined. The

thorough emulsification of Cod-liver Oil can only be carried out by special mechanical appliances.

The writer has examined over a hundred varieties of Cod-liver Oil Emulsion, and many were found to separate at ordinary temperatures, a condition which made a uniform dose impossible, and others were imperfectly mixed, showing small clots or lumps. Scott's Emulsion never separated, and was so perfectly emulsified that it could be drawn readily through a capillary tube until the bottle was emptied.

These properties made this Emulsion highly suitable for the experiments.

### **Dose.**

**DOSE:** A uniform dose of 0·3 cc. (or a little over 5 minims) of Cod-liver Oil was given daily per 2 lbs. of the animal weight during the whole course of the experiments, one-half of which was given with the morning meal, and one-half with the evening meal; this is equivalent to 5 teaspoonfuls of Cod-liver Oil per diem for a man weighing 120 lbs.

When the amount of Cod-liver Oil appeared to disagree it was reduced by one-half for a time. The oil was mixed with a small quantity of food, which was given first, the remainder of the meal being given after the oil had been entirely taken.

## 20 INFLUENCE OF COD-LIVER OIL

In order that the experiments should be scientifically comparable it was necessary to give a dose of Cod-liver Oil Emulsion which contained the same quantity of Cod-liver Oil, viz., 0·7 cc. (11·8 minims) per 2 lbs. weight of animal, or the equivalent of nearly three tablespoonfuls of Emulsion per diem for a man of 120 lbs. weight. In the case of plain Cod-liver Oil it was not possible always to give it without sometimes causing discomfort to the animals; but the Emulsion was always readily taken, and there was never any discomfort following.

The experiments demonstrated that dose for dose the Emulsion was greatly superior to Cod-liver Oil.

It was not necessary to give so large a quantity of Emulsion in order to obtain benefit, but to get strictly comparable results.

Beneficial results were demonstrated by the Emulsion which were not given by plain Cod-liver Oil, and Scott's Emulsion is therefore a superior remedy to Cod-liver Oil, and it may also be said that within the limits of the maximum and minimum dose that bulk for bulk, teaspoonful for teaspoonful, the same is true.

## ANIMALS USED.

### 1st Set, 1904.

After several unsuccessful attempts had been made in 1904 to obtain a first set of six pigs, all of the same breed and of the same age, three pairs were obtained. These were from three litters; four of them were pure-bred white Yorkshire pigs, in good condition, took their food well and were considered suitable for experiment. The other two, on the contrary, did not thrive, and were not used for experiment. Of the four suitable for experiment, two were 7 weeks and 4 days, the other two were 5 weeks and 2 days old when they reached the laboratory. The younger pigs were selected for the experiments, in which tuberculosis was produced by ingestion. The older pigs were infected by inoculation.

### 2nd Set, 1906.

Early in 1906 we were successful in obtaining seven white Yorkshire pigs 7 weeks old. These pigs were from two litters, but were all robust, healthy-looking and suitable for experiments.

### Feeding.

To the first set of pigs the amount of food given daily was calculated on the following basis:—

## 22 INFLUENCE OF COD-LIVER OIL

Of skimmed milk, about  $\frac{1}{12}$ th of the body weight. Of a mixture of 3 parts of barley meal (thirds) and of 1 part of bran,  $\frac{1}{40}$ th of the body weight.

The meal was mixed with an equal part of water, one-half of the water was boiled, and while hot was mixed with the meal, the remaining half being added afterwards.

The pigs took this warm food very readily from the first. They were fed twice a day, one-half of the food being given in the morning, and the other half in the evening.

To the second set of pigs no milk was given, and, on the advice of the breeder, the food consisted entirely of barley meal (sharps or middlings) and water. The meal was prepared as in the previous experiments, but the amount of water was increased, 3 parts of water being added to 1 part of dry meal. For about a month the amount of meal given daily was calculated so as to be about  $\frac{1}{16}$ th part of the body weight. It was found, however, that none of the pigs would take this amount of food, of which much was wasted.

At the end of the first month an excess of food was given for two weeks; the amount of food left after each meal was measured, and after this the



amount of food given was only slightly in excess of what the pigs were able to eat readily.

It was thus found that the amount of dry meal had to be reduced to about  $1/_{26}$ th part of the body weight of the animal.

This quantity was almost always taken rapidly and without waste by six of the pigs (*viz.*, pigs 1645, 1646, 1647, 1648, 1649, 1650). Pig 1644 left generally only a small portion of its evening meal. This inability to take the food properly was obviously due to the addition of the oil.

In the first set of experiments one pig (1501) showed at times a distinct dislike for Cod-liver Oil, and this also for a time interfered with its feeding. The same tendency was also exhibited by pig (1644). It is obvious that this dislike for food caused by the addition of Cod-liver Oil interfered to a certain extent with the regularity of the results obtained, and that it made it difficult to push the feeding of the animals, which took their food well, as much as might have been done if some of the pigs had not refused their food. Thus none of the pigs taking the emulsion showed any dislike for their food, and they very seldom left any, so that it is probable that they could have eaten more than was given to them had it not been found necessary to keep the proportion

## 24 INFLUENCE OF COD-LIVER OIL

of food given to the various pigs as uniform as possible.

From the ninth week to the end of the experiment not only the amount of food given daily, but also the amount left after each meal, was weighed regularly, so that it is easy to see in the tabulated record of the experiments to what an extent the want of appetite interfered with the results obtained. It is well known that it is desirable to introduce some variety in the diet of pigs, but the nature of the experiments made it undesirable to introduce variations which might have made the interpretation of results difficult. It is also obvious that the composition of the food could not be regulated by the usual considerations upon which are based methods of feeding for fattening purposes. The chief object was to feed all the pigs on a similar fashion, to give them a quantity of food which they could easily digest and which would be sufficient to maintain a fair rate of growth.

### **Housing.**

Each pig was kept in a separate sty. All the sties were exactly of the same size, shape and construction. They consisted of a small wooden shed, raised about 9 inches above the concreted court; they were well ventilated and dry. Each

shed opened into a small run, the floor of which was concreted and well drained. All the sties were parallel to each other, facing south, and equally protected from cold and rain. The sties were cleaned daily, and always free from any bad smell. Briefly speaking, all the animals were kept under conditions as identical as it was practically possible to make them.

### **Weighing.**

The pigs of the first set were weighed regularly three times a week; those of the second set were weighed twice a week, one day in the morning, the other day in the evening, so as to divide the week equally. The weight was taken before meals. The weekly average weights recorded in the tables were calculated on the basis of these weighings.

## **DIVISION OF THE EXPERIMENTS INTO 4 STAGES.**

The observations relating to each pig may be subdivided as follows:—

### **1st—Preliminary Stage.**

After being placed in the sties and given the kind of food which they were to have during the remainder of the experiments, the pigs of the first set were kept under observation for a period of nearly two weeks, and those of the second set for a period of one month. Two of the pigs belonging to the first set did not thrive well, and were rejected. All the other pigs seemed in good condition, and increased steadily in weight, with the exception of pig 1648, which remained stationary for nearly two weeks. But as that pig was otherwise apparently healthy, it was used for one of the Cod-liver Oil Emulsion experiments. During the last fortnight of the period the average increase in weight of each pig was calculated, and the pigs grouped, so that each substance was tested on two or four pigs, showing together a rate of increase as near as possible similar to that of the pigs of the other groups.

## 2nd—Second Stage.

In the second stage the effects of the administration of Cod-liver Oil and Cod-liver Oil Emulsion to the animals were observed. The pigs were divided into two groups—A and B.

A. Pigs 1500 and 1503 were given the same food as the others, but no oil. These pigs were used to control the results obtained with the first set of pigs, and were kept under observation for eight weeks.

B. All the other pigs were given Cod-liver Oil or Cod-liver Oil Emulsion, and were kept under observation for various periods before anything else was done to them.

1644, 1647, 1648, 1649, 1650 for  $2\frac{1}{2}$  weeks.

1504, 1505 for 6 weeks.

1501, 1502 for 8 weeks.

1645, 1646 for 19 weeks.

## 3rd—Third Stage.

In the third stage the effects of tuberculous infection upon pigs taking Cod-liver Oil and Cod-liver Oil Emulsion were studied.

All the pigs but two (1645 and 1646, which were kept as controls) were rendered tuberculous, and then kept under observation as before.

A. Two pigs (1500 and 1501) were infected by

## 28 INFLUENCE OF COD-LIVER OIL

the addition of the two meals given in one day, of about  $2\frac{1}{2}$  ounces of a mixture of tuberculous liver and tuberculosis lymphatic gland of a cow ( $1\frac{1}{4}$  ounces given with each meal).

To 1500 no oil was administered.

To 1501 Cod-liver Oil was administered.

These two pigs were kept under observation for  $6\frac{1}{2}$  weeks after being infected.

B. Two pigs (1503, 1504) were infected in the following way:—

They were first inoculated subcutaneously on the inner aspect of the left leg with  $\frac{1}{10}$  cc. of an emulsion made with a pure culture of human tubercle bacilli, which had been passed successively through a calf and through a guinea-pig.

Three weeks later they were again inoculated, this time in the right leg, with an emulsion made with a tuberculous mediastinal gland of a cow; after this second inoculation they were kept under observation for  $6\frac{1}{2}$  weeks.

C. Five pigs (1644, 1647, 1648, 1649, 1650) were inoculated subcutaneously in the left leg with  $\frac{1}{5}$  cc. of a pure culture of human tubercle bacilli, which had not been passed through any animal.

Three weeks after the first inoculation these pigs were inoculated again, in the right leg, with

an emulsion made with the tuberculous spleen and lymphatic ganglia of a guinea-pig which had been infected with the milk of a tuberculous cow.

The number of bacilli injected into each pig at this last inoculation was enumerated, and estimated to be on an average 4,000. The activity of the products used for infecting the pigs was tested carefully before the experiments were entered upon.

Three of these pigs were kept under observation for eight weeks after the last inoculation (1644, 1647, 1649).

Two of them (1648, 1650) were kept under observation for 23 weeks.

#### **4th Stage.**

Every one of the pigs of the first series, after being kept under observation for a time sufficient to allow the effects of the feeding, administration of oil and inoculation to be observed, was then killed and examined carefully post mortem.

It was thought desirable to kill two animals at an early stage in order to compare the state of early with that of late lesions in the case of Cod-liver Oil Emulsion.

### 30 INFLUENCE OF COD-LIVER OIL

At the autopsy the following points were specially noted :—

1st. Characters of local lesions.

2nd. Lymphatic glands affected.

3rd. State of the liver, spleen, lungs and kidneys.

4th. General state of the carcase.

5th. The presence or absence of tubercle bacilli was ascertained by microscopical examination of suitably stained films and microscopical sections. In one case guinea-pigs were also inoculated to establish the nature of doubtful lesions.



*Record of Results of the  
Experiments.*



## RECORD OF RESULTS OF THE EXPERIMENTS.

A detailed account of all the observations made would occupy a considerable amount of space and be unnecessary.

These observations have therefore, with Prof. Delépine's assistance, been tabulated and summarised as follows: The average amount of food given and taken, the weight of each animal during each week has been calculated from the daily records. From the average weekly weight the daily rate of increase of weight has been calculated on the supposition that each pig weighed at the beginning of each fortnightly period exactly 100lbs.

In the tables I. to XI. the observations relating to each pig are given in various columns in the following order:—

Column.

1. Week of experiment.
2. Age of pig in days at the beginning of each week of the experiment.
3. Average amount of dry food (meal) given weekly.

## 34 INFLUENCE OF COD-LIVER OIL

1500—1504. Tables I.—IV.

Column.

4. Average amount of water given weekly.
5. Average amount of milk given weekly.

1644—1648. Tables V.—XI.

3.  $\times$  Amount of food (ready mixed) given weekly.
4.  $\times$  Amount of food (ready mixed) taken weekly.
5.  $\times$  Amount of dry meal taken weekly.
6. Average weight during each week (therefore approximate weight at the middle of each week).
7. Daily average increase (+) or decrease (−) during each period of 14 days reduced to a supposed uniform weight of 100 lbs. at the beginning of each period of 14 days.
8. Amount of oil administered weekly.
9. Modes of infection.
10. Remarks, including dates of beginning and ending of each experiment, also dates of inoculation or feeding with tuberculous products and evidences of ill-health.

TABLE I.—No. of Pig, 1500. (No Oil.) (Control and tuberculous infection.)

1	2	3	4	5	6	7	8	9	10
Week of Experiment.	Age. Days.	Dry Food. ozs.	Food given weekly. Water. ozs.	Milk ozs.	Average weight weekly.	Daily increase or decrease % fortnightly periods.	Oil given weekly. Ccs.	Tuberculous infection.	Remarks.
1st stage ... 1.	59 ...	66 ...	96 ...	240 ...	26.0 ...	+ 2.2 ...	No oil ...		Special feeding begun May 31st 1904. Observations begun June 6th, 1904. Food well taken, and very little wasted.
2nd stage ... 2.	66 ...	77 ...	112 ...	280 ...	30.0 ...	+ 2.0 ...			
3.	73 ...	112 ...	112 ...	280 ...	33.3 ...				
4.	80 ...	112 ...	128 ...	280 ...	38.3 ...				
5.	87 ...	112 ...	168 ...	280 ...	44.9 ...	+ 2.08 ...			
6.	94 ...	124 ...	168 ...	280 ...	49.7 ...				
7.	101 ...	140 ...	168 ...	280 ...	51.5 ...	+ 0.62 ...			
8.	108 ...	140 ...	168 ...	280 ...	54.1 ...				
3rd stage ... 9.	115 ...	140 ...	168 ...	280 ...	57.7 ...	+ 0.90 ...			Ingestion 1/6th August 6th, end 9th week. 1/12th lb. given with morning and 1/12th lb. given with evening meal
10.	123 ...	140 ...	168 ...	280 ...	61.0 ...				
11.	129 ...	140 ...	168 ...	280 ...	62.6 ...				
12.	136 ...	140 ...	168 ...	280 ...	59.8 ...	- 0.13 ...			
13.	143 ...	140 ...	168 ...	280 ...	62.6 ...	+ 0.23 ...			
14.	150 ...	140 ...	168 ...	280 ...	61.8 ...				
15.	157 ...	140 ...	168 ...	280 ...	59.1 ...				Killed Sept. 20th, 1904.
16.	174 ...	140 ...	168 ...	280 ...	58.5 ...	- 0.37 ...			
4th stage ... P.M.									Supercil lymphatic glands, normal. Lumbar glands, normal. Tubercle bacilli found in the mesenteric glands. No evidence of bacterial disease other than tuberculosis.



TABLE II.—No. of Pig, 1501. (Cod Liver Oil). (Control and tuberculous infection).

1	2	3	4	5	6	7	8	9	10
Week of Experiment.	Age (days).	Dry Food. Ozs.	Food Water. Ozs.	Milk given weekly. Milk. Ozs.	Average weight weekly.	Daily increase or decrease % fortnightly periods.	Oil given weekly. Ccs.	Tuberculous infection.	Remarks.
1st stage ... 1.	59	... 66	... 96	... 240	... 25·2	+ 2·1	... 49·0		Special feeding begun May 31 1904. Observations June 6th, '04. Food taken well.
2nd stage... 2.	66	... 77	... 112	... 280	... 29·0				
3.	73	... 112	... 112	... 280	... 32·6	+ 2·08	... 61·6		
4.	80	... 112	... 128	... 280	... 37·3		... 64·4		
5.	87	... 112	... 168	... 280	... 39·7	+ 1·07	... 73·8		Animal takes food less readily after addition of oil. Vomited 1 dose of oil.
6.	94	... 124	... 168	... 280	... 43·0		... 77·6		
7.	101	... 140	... 168	... 280	... 45·0	+ 0·37	... 81·6		
8.	108	... 140	... 168	... 280	... 45·3		... 85·8		
9.	115	... 140	... 168	... 280	... 47·5	+ 0·77	... 96·6	Ingestion 1/6th lb of tuberculous liver and lymphatic gland of cow.	Aug. 6th, end of 9th week 1/12th lb. at morning, 1/12th at evening meal.
10.	122	... 140	... 168	... 280	... 50·3				
11.	129	... 140	... 168	... 280	... 50·8	- 0·19	... 96·0		
12.	136	... 140	... 168	... 280	... 49·0		... 94·0		
13.	143	... 140	... 168	... 280	... 52·0	+ 0·42	... 92·4		
14.	150	... 140	... 168	... 280	... 52·0		... 187·2		
15.	157	... 140	... 168	... 280	... 51·6	- 0·09	... 205·0		
16.	164	... 140	... 168	... 280	... 51·2		... 82·3		Killed Sept. 20, 1904.

4th stage... P.M. .. In the same state as 1500. Tubercle bacilli found in mesenteric and retrohepatic glands.





TABLE III.—Fig No. 1503. No oil. (Tuberculous infection).

1	2	3	4	5	6	7	8	9	10
Week of Experiment.	Age (days).	Amount of Food given ozs.	Water. ozs.	Milk. ozs.	Average weight weekly.	Daily increase or decrease % fortnightly periods.	Oil given weekly. Ccs.	Tuberculous infection.	Remarks.
1st stage ... 1.	45 ...	66 ..	96 ..	240 ...	26·1	} + 1·9 ...	}		Special feeding begun May 31, 1904. Observations begun June 6, 1904. Food taken very well. Human tubercle bacilli.
2nd stage ... 2.	52 ...	77 ..	112 ..	280 ...	29·7				
3.	59 ..	112 ..	112 ..	280 ...	33·6				
4.	66 ...	112 ...	128 ...	280 ...	40·4				
5.	73 ...	112 ...	168 ...	280 ...	46·0				
3rd stage ... 6.	80 ...	124 ...	168 ...	280 ...	50·5	} + 1·7 ...	}		Human tubercle bacilli.
7.	87 ...	140 ...	168 ...	280 ...	53·0				
8.	94 ...	140 ...	168 ...	280 ...	55·1				
9.	101 ...	140 ...	168 ...	280 ...	58·6				
10.	108 ...	140 ...	168 ...	280 ...	62·5				
11.	115 ...	140 ...	168 ...	280 ...	64·7	} + 0·28 ...	}		Bovine tuberculous 1 cc. of emulsion of lymphatic gland.
12.	122 ...	140 ...	168 ...	280 ...	65·0				
13.	129 ...	140 ...	168 ...	280 ...	68·0				
14.	136 ...	140 ...	168 ...	280 ...	68·3				
15.	143 ...	140 ...	168 ...	280 ...	67·5				
16.	150 ...	140 ...	168 ...	280 ...	67·2	} - 0·05 ...	}		Killed September 20, 1904.
4th stage ... P.M.	...	...	...	...	...				

*Subcutaneous tuberculous mass* at the seat of inoculations in the left hind leg. No distinct lesion on the right side. The glands above the diaphragm are normal looking. Tubercle bacilli were found in the left inguinal gland, right inguinal and left local lesion. No evidence of bacterial disease other than tuberculosis.



TABLE IV.—Pig No. 1504. Cod Liver Oil. (Tuberculous infection).

1	2	3	4	5	6	7	8	9	10
Week of Experiment.	Age (days).	Dry Food, ozs.	Amount of Food given weekly. Water, ozs.	Milk, ozs.	Average weight, weekly.	Daily increase or decrease % fortnightly periods.	Oil given weekly. Gms.	Tuberculous infection.	Remarks.
1st stage ... 1.	45 ...	66 ...	96 ...	240 ...	22.0 ...	+ 2.1 ...	33.0 ...	...	Special feeding begun May 31st, 1904. Observations begun June 6th, 1904. Oil begun third day of second week.
2nd stage ... 2.	52 ...	77 ...	112 ...	280 ...	25.3 ...	...	...	...	...
3.	59 ...	112 ...	112 ...	280 ...	29.0 ...	+ 2.7 ...	51.2 ...	...	...
4.	66 ...	112 ...	128 ...	280 ...	35.1 ...	...	56.8 ...	...	...
5.	73 ...	112 ...	168 ...	280 ...	41.0 ...	...	70.6 ...	...	...
3rd stage ... 6.	80 ...	124 ...	168 ...	280 ...	45.0 ...	+ 2.0 ...	79.4 ...	Human tubercle bacilli	July 15th, 1904, end of sixth week, also g.p. 1522, 1/10th culture on potato.
7.	87 ...	140 ...	168 ...	280 ...	47.9 ...	+ 0.91 ...	85.8 ...	...	...
8.	94 ...	140 ...	168 ...	280 ...	51.0 ...	...	91.0 ...	...	...
9.	101 ...	140 ...	168 ...	280 ...	53.3 ...	+ 0.98 ...	117.4 ...	Bovine tuberculosis	August 5th, 1904, end of ninth week, also g.p. 1538, 1 cc. of thick emulsion of lymphatic gland (tuberculous)
10.	108 ...	140 ...	168 ...	280 ...	58.0 ...	...	...	...	...
11.	115 ...	140 ...	168 ...	280 ...	60.0 ...	+ 0.13 ...	135.0 ...	...	...
12.	122 ...	140 ...	168 ...	280 ...	59.1 ...	...	168.8 ...	...	...
13.	129 ...	140 ...	168 ...	280 ...	61.0 ...	+ 0.30 ...	168.0 ...	...	...
14.	136 ...	140 ...	168 ...	280 ...	61.8 ...	...	224.4 ...	...	...
15.	143 ...	140 ...	168 ...	280 ...	61.3 ...	- 0.06 ...	225.8 ...	...	Killed Sept. 20th, 1904
16.	150 ...	140 ...	168 ...	280 ...	61.2 ...	...	...	...	...

4th stage ... P.M.

The lesions are almost identical with those found in 1503. Tubercle bacilli were found in the left superficial inguinal glands, and also in the right and left sacro-lumbar glands and in the retrohepatic gland, and left local lesion.



TABLE V.—Pig No. 1644. Cod Liver Oil. (Tuberculous infection).

1	2	3x	4x	5x	6	7	8	9	10
Week of Experiment.	Age (days).	Amount of Food weekly.		Dry Meal ozs.	Average weight weekly.	Daily increase or decrease % fortnightly periods.	Oil given weekly. Ozs.	Tuberculous infection.	Remarks.
		Given w'kly ozs.	Taken w'kly ozs.						
1st stage ...	1.	93 ...	abt. 450 ...	ab. 112...	24·3	} + 0·53	24·0 ...	...	Special feeding begun May 15, Observations begun May 20, '05. Oil begun 1 day before end of second week. 1 day before the end of 5th week.
2.	100 ...	672 ...	?	...	25·5		56·0 ...	...	
3.	107 ...	672 ...	?	...	26·1		56·0 ...	...	
4.	114 ...	672 ...	?	...	27·2		...	...	
						} + 0·90		...	
3rd stage ...	5.	121 ...	672 ...	?	...	} + 0·61	61·6 ...	Human tuber- culosis.	Middle of 8th week.
6.	128 ...	672 ...	?	...	31·3		62·8 ...	...	
7.	135 ...	896 ...	abt. 500	...	32·1		62·2 ...	...	
8.	142 ...	896 ...	abt. 500	...	32·2		67·2 ...	...	
9.	149 ...	504 ...	468 ...	117 ...	34·3	} + 0·46	68·4 ...	Bovine tuber- culosis.	Animal vomited middle of 13th week.
10.	156 ...	504 ...	417 ...	104 ...	35·3		71·4 ...	...	
11.	163 ...	504 ...	480 ...	120 ...	35·8		71·8 ...	...	
12.	170 ...	504 ...	492 ...	123 ...	36·1		72·8 ...	...	
13.	177 ...	504 ...	384 ...	96 ...	34·7	} - 0·22	72·8 ...	...	Killed Sept. 5, 1905.
14.	184 ...	504 ...	492 ...	123 ...	33·0		72·8 ...	...	
15.	191 ...	504 ...	480 ...	120 ...	34·3		72·8 ...	...	
16.	198 ...	180 ...	168 ...	42 ...	35·5		26·0 ...	...	

4th stage ... P.M.

201 ... No evidence of any bacterial disease other than tuberculosis. The tuberculous lesions are clearly connected with the seats of inoculation in the two hind legs. Tubercle bacilli were found in the local lesions and in the inguinal, sacrolumbar glands, and popliteal glands.

The 3 columns show: 3x, amount of food, including water given weekly; 4x, amount of that food taken weekly by the pig; 5x, actual amount of dry meal contained in the food taken.



TABLE VI.—Fig. No. 1645.

## Cod Liver Oil.

(Control—no infection).

1	2	3 x	4 x	5 x	6	7	8	9	10	
Week of Experiment.	Age (days).	Amount of Food weekly.			Average weight weekly.	Daily increase or decrease % fortnightly periods.	Oil given weekly Ccs.	Tuberculous infection.	Remarks.	
		Ozs.	Given w'kly	Taken w'kly	Dry Meal Ozs.					
1st stage ... 1.	93 ...	560 ...	abt.	450 ...	? ...	19.0	18.0 ...	No infection	Special feeding begun May 15th, 1905. Observations begun May 20th. Oil begun one day before end of second week. Pig takes it without difficulty and appears to like it.	
2.	100 ...	560 ...	„	450 ...	? ...	20.0	+ 0.73 ...			
2nd stage ... 3.	107 ...	560 ...	„	450 ...	? ...	21.0	42.8 ...			
4.	114 ...	560 ...	„	450 ...	? ...	22.3	44.8 ...			
5.	121 ...	560 ...	„	450 ...	? ...	23.6	+ 0.85 ...			
6.	128 ...	560 ...	„	450 ...	? ...	25.0	+ 0.50 ...			
7.	135 ...	728 ...	„	450 ...	112 ...	25.3	+ 0.59 ...			
8.	142 ...	728 ...	„	450 ...	112 ...	26.8	+ 0.65 ...			
9.	149 ...	504 ...	„	450 ...	112 ...	27.5	+ 0.53 ...			
10.	156 ...	504 ...	„	480 ...	120 ...	28.7	+ 0.86 ...			
11.	163 ...	504 ...	„	504 ...	126 ...	30.0	+ 0.38 ...			
12.	170 ...	504 ...	„	480 ...	120 ...	30.7	Cod liver oil stopped			
13.	177 ...	504 ...	„	504 ...	126 ...	32.3	75.6 ...			
14.	184 ...	504 ...	„	492 ...	120 ...	34.0	Cod liver oil stopped			
15.	191 ...	504 ...	„	492 ...	120 ...	36.2	end of			
16.	198 ...	504 ...	„	504 ...	126 ...	38.7	16th week			
17.	205 ...	504 ...	„	504 ...	126 ...	38.2	+ 1.26 ...			
18.	212 ...	504 ...	„	504 ...	126 ...	40.6				
19.	219 ...	504 ...	„	504 ...	126 ...	41.0				
20.	226 ...	504 ...	„	504 ...	126 ...	43.0				
21.	233 ...	288 ...	„	288 ...	72 ...	46.2				
4th stage P.M.	237 ...	Animal spare.	Curcase and viscera appear healthy.							
...										

Cod liver oil replaced by Scott's emulsion beginning of seventh week (167 cc. of Scott's emulsion weekly). Animal killed Oct. 12th, 1905.





TABLE VII.—Pig No. 1646. Scott's Emulsion. (Control of Infection).

1	2	3x	4x	5x	6	7	8	9	10
Week of Experiment.	Age (days).	Amount of Food weekly.			Average weight weekly.	Daily increase or decrease % fortnightly periods.	Oil given weekly Ozs.	Tuberculous infection.	Remarks.
		Given w'kly ozs.	Taken w'kly ozs.	Dry Meal ozs.					
1st stage ... 1.	93	876	abt. 550	?	33.7	+ 0.88	75.0	No infection	Special feeding begun May 15, '05.
2.	100	876	" 550	?	35.8				
2nd stage ... 3.	107	876	?	?	38.0	+ 0.80	178.2	...	Observations begun May 20, '05.
4.	114	876	?	?	39.0				
5.	121	876	?	?	42.7	+ 0.96	191.8	...	Emulsion begun 1 day before the end of 2nd week.
6.	128	876	?	?	47.1				
7.	135	1344	" 900	?	48.7	+ 1.31	232.0	...	...
8.	142	1344	" 900	?	54.3				
9.	149	924	" 888	222	57.7	+ 0.78	247.6	...	...
10.	156	924	924	231	61.1				
11.	163	924	924	231	64.1	+ 0.48	284.4	...	...
12.	170	924	924	231	66.7				
13.	177	924	924	231	68.5	+ 0.77	316.4	...	...
14.	184	924	924	231	72.0				
15.	191	924	924	231	76.0	+ 0.32	332.4	...	...
16.	198	924	924	231	79.0				
17.	205	924	924	231	79.6	+ 0.45	—	—	...
18.	212	924	924	231	82.3				
19.	219	924	924	231	84.7	+ 0.60	—	—	...
20.	226	924	924	231	86.6				
21.	233	510	570	231	92.0				

Killed Oct. 12, '05.

4th stage ... P.M. 237 ... Animal well nourished, internal organs appear healthy.



TABLE VIII.—Pig No. 1647. Scott's Emulsion. (Tuberculous infection.)

1	2	3 x	4 x	5 x	6	7	8	9	10	
Week of Experiment.	Age (days).	Amount of Food weekly.			Average weight weekly.	Daily increase or decrease % fortnightly periods.	Oil given weekly. Ccs.	Tuberculous infection.	Remarks.	
		Given w'kly ozs.	Taken w'kly ozs.	Dry meal ozs.						
1st stage...	1.	93 ...	abt. 550 ...	?	34.6	} + 0.80	78.0 ...	...	Special feeding begun May 15, 1905. Observations begun May 20, 1905. Emulsion begun 1 day before the end of 2nd week. Pig takes it without difficulty and appears to like it. 1 day before the end of 5th week. Middle of 8th week. Last day of 10th week, pig escaped and injured both hind legs.	
	2.	100 ...	952 ...	?	37.3					
2nd stage...	3.	107 ...	952 ...	?	38.6	} + 1.0	183.6 ... 187.6 ... 194.4 ...	...		Human tuberculosis.
	4.	114 ...	952 ...	?	40.6					
3rd stage ...	5.	121 ...	952 ...	?	44.1	} + 0.97	223.0 ... 235.8 ...	...	Killed Sep. 6, 1905	
	6.	128 ...	952 ...	?	47.6					
	7.	135 ...	1400 ...	?	50.2					
8.	142 ...	1400 ...	900 ...	?	55.6	} + 1.23	247.8 ... 255.8 ...	...		Bovine tuberculosis.
9.	149 ...	924 ...	924 ...	231 ...	59.0					
10.	156 ...	924 ...	924 ...	231 ...	61.8	} + 0.57	275.8 ... 285.0 ...	...		
11.	163 ...	924 ...	924 ...	231 ...	63.8					
12.	170 ...	924 ...	924 ...	231 ...	63.5	} + 0.20	308.0 ... 308.0 ...	...		
13.	177 ...	924 ...	924 ...	231 ...	65.7					
14.	184 ...	924 ...	924 ...	231 ...	67.1	} + 0.42	308.0 ... 317.6 ...	...		
15.	191 ...	924 ...	924 ...	231 ...	69.6					
16.	198 ...	330 ...	288 ...	231 ...	72.0	+ 0.53	170.8 ...	...		

4th stage ...

202 ...No evidence of any bacterial disease other than tuberculosis. The tuberculous lesions are clearly connected with the seat of inoculation in the two hind legs. Tubercle bacilli were found in all the lesions. There was no extension of the disease to the glands above the diaphragm.

P.M.



TABLE IX. Pig No. 1648. Scott's Emulsion. (Tuberculous infection.)

1	2	3 x	4 x	5 x	6	7	8	9	10
Week of Experiment.	Age (days)	Amount of Food w'kly Ozs.	Amount of Food w'kly Taken w'kly Ozs.	Dry meal Ozs.	Average weight, weekly	Daily increase or decrease % fortnightly periods.	Oil given weekly, Ozs.	Tuberculous infection.	Remarks.
1st stage ... 1.	93 ...	728 ...	abl. 550	?	30.5	+ 0.29	...	...	Special feeding begun May 15th, 1905. Observations begun May 20th, 1905. Oil begun one day before end of second week. Pig continued to take food and emulsion very well.
2.	100 ...	728 ...	" 550	?	30.3		66.0	...	
2nd stage ... 3.	107 ...	728 ...	" 550	?	31.8	+ 0.80	154.8	...	
4.	114 ...	728 ...	" 550	?	33.0		156.8	...	
3rd stage ... 5.	121 ...	728 ..	" 550	?	35.7		161.6	...	
6.	128 ...	728 ...	" 550	?	38.8	+ 1.12	177.6	...	
7.	135 ...	1120 ...	" 700	?	41.2		186.0	...	
8.	142 ...	1120 ...	" 700	?	45.8	+ 1.20	—	...	
9.	149 ...	756 ...	744	186	48.5		212.2	...	
10.	156 ...	756 ...	756	189	52.4	+ 0.97	235.2	...	
11.	163 ...	756 ...	756	189	55.1		244.8	...	Human tuberculosis ... One day before the end of fifth week. Middle of eighth week.
12.	170 ...	756 ...	756	189	60.0	+ 0.88	268.8	...	
13.	177 ...	756 ...	756	189	62.0		268.8	...	
14.	184 ...	756 ...	678	169.5	65.3	+ 0.66	268.8	...	
15.	191 ...	756 ...	756	189	67.8		287.2	...	
16.	198 ...	756 ...	756	189	71.8	+ 0.51	333.2	...	
17.	205 ...	756 ...	756	189	72.8		340.4	...	
18.	212 ...	756 ...	756	189	73.3	+ 0.42	358.4	...	
19.	219 ...	756 ...	756	189	77.2		358.4	...	

TABLE IX.—Continued.

Pig No. 1648. Scott's Emulsion. (Tuberculous infection.)

1	2	3 ×	4 ×	5 ×	6	7	8	9	10
Week of Experiment.	Age (days)	Given wkly ozs.	Amount of Food Taken wkly ozs.	Dry meal ozs.	Average weight weekly	Daily increase or decrease % fortnightly periods.	Oil given weekly Ccs.	Tuberculous infection.	Remarks.
20.	226 ...	756 ...	756 ...	... 189	... 80.1	+ 0.58	358.4 ...	...	
21.	233 ...	756 ...	756 ...	... 189	... 83.5	...	358.4 ...	...	
22.	240 ...	756 ...	756 ...	... 189	... 87.6	+ 0.43	358.4 ...	...	
23.	247 ...	756 ...	756 ...	... 189	... 88.6	...	278.8 ...	...	
24.	254 ...	756 ...	756 ...	... 189	... 92.3	+ 0.42	358.4 ...	...	
25.	261 ...	756 ...	756 ...	... 189	... 94.0	...	358.4 ...	...	
26.	268 ...	756 ...	756 ...	... 189	... 96.1	- 0.09	358.4 ...	...	
27.	275 ...	756 ...	648 ...	... 162	... 92.7	...	358.4 ...	...	
28.	282 ...	756 ...	750 ...	... 187.5	... 91.3	- 0.01	358.4 ...	...	
29.	289 ...	756 ...	642 ...	... 160.5	... 92.5	...	358.4 ...	...	
30.	296 ...	756 ...	666 ...	... 166.5	... 92.7	- 0.02	358.4 ...	...	
32.	303 ...	162 ...	96 ...	... —	... 89.5	...	358.4 ...	...	

4th stage... P.M. Notes. The amount of tuberculous infection was very similar to that found in pig 1650.

TABLE X.—Pig No. 1649. Scott's Emulsion. (Tuberculous infection).

1	2	3 x	4 x	5 x	6	7	8	9	10
Week of Experiment.	Age (days)	Amount w'kly Given ozs.	Amount of Food Taken w'kly ozs.	Dry meal ozs.	Average weight weekly.	Daily increase or decrease % fortnightly periods.	Oil given weekly. Ozs.	Tuberculous infection.	Remarks.
1st stage ... 1.	93	... 1012	...	...abt. 750...	37.2	} + 0.75	...	...	Special feeding begun May 15, '05. Observations begun May 20, '05. Emulsion begun 1 day before end of second week.
2.	100	...iner'sug...	—	...iner'sug...	39.7		84.0	...	
2nd stage... 3.	107	...	—	?	41.1	} + 1.2	197.6	...	Pig continues to take food and emulsion well.
4.	114	...	—	?	43.0		201.6	...	
3rd stage ... 5.	121	...	—	?	47.0	} + 1.02	208.4	...	Human tuber- 1 day before the end of 5th week.
6.	128	...	—	?	51.0		231.8	...	
7.	135	... 1680	...abt. 900...	?	53.7	} + 1.04	253.0	...	Bovine tuber- Middle of 8th week.
8.	142	... 1680	... 900...	?	58.6		266.0	...	
9.	149	... 924	... 888	222	61.6	} + 0.65	276.0	...	Bovine tuber- Middle of 8th week.
10.	156	... 924	... 912	228	64.3		301.0	...	
11.	170	... 924	... 924	231	67.3	} + 0.66	309.0	...	Bovine tuber- Middle of 8th week.
12.	170	... 924	... 924	231	70.8		329.0	...	
13.	177	... 924	... 924	231	73.5	} + 0.58	329.0	...	Bovine tuber- Middle of 8th week.
14.	184	... 924	... 924	231	76.0		329.0	...	
15.	191	... 924	... 924	231	79.5	} + 0.71	345.4	...	Animal killed Sep. 6, 1905.
16.	198	... 330	... 288	231	83.5		193.2	...	

4th stage ... The only evidences of bacterial disease were the subcutaneous lesions at the seat of inoculations in both hind legs and the tuberculous lesions of the inguinal and sacrolumbar glands connected with the infected parts. The lesions in the left side were more marked than on the right. Tubercle bacilli were found in the glands below the diaphragm but not in those above.

P.M.





TABLE XI.—Pig No. 1650. Scott's Emulsion. (Tuberculosis infection).

1	2	3x	4x	5x	6	7	8	9	10
Week of Experiment.	Age (days).	Amount of Food weekly.			Average weight	Daily increase or decrease % fortnightly periods.	Oil given weekly. Ccs.	Tuberculous infection.	Remarks.
		Given w'kly ozs.	Taken w'kly ozs.	Dry meal ozs.					
1st stage ... 1.	93	...	1012 ...	abt. 750 ...	?	?	?	?	?
2.	100	...	inc'sing ...	inc'sing ...	...	...	...	...	...
2nd stage... 3.	107	...	"	"	...	...	...	...	...
4.	114	...	"	"	...	...	...	...	...
5.	121	...	"	"	...	...	...	...	...
6.	128	...	"	"	...	...	...	...	...
7.	135	...	1680 ...	abt. 1000 ...	?	?	?	?	?
8.	142	...	1680 ...	" 1000 ...	?	?	?	?	?
9.	149	...	1092 ...	1086 ...	271.5 ...	68.0	...	...	...
10.	156	...	1092 ...	1092 ...	273.0 ...	71.7	...	...	...
11.	163	...	1092 ...	1092 ...	273.0 ...	74.5	...	...	...
12.	170	...	1092 ...	1092 ...	273.0 ...	79.1	...	...	...
13.	177	...	1092 ...	1092 ...	273.0 ...	81.2	...	...	...
14.	184	...	1092 ...	1092 ...	273.0 ...	84.3	...	...	...
15.	191	...	1092 ...	1092 ...	273.0 ...	89.6	...	...	...
16.	198	...	1092 ...	1092 ...	273.0 ...	93.5	...	...	...
17.	205	...	1092 ...	1092 ...	273.0 ...	95.1	...	...	...
18.	212	...	1092 ...	1092 ...	273.0 ...	99.7	...	...	...
19.	219	...	1092 ...	1032 ...	234.8 ...	101.8	...	...	...
20.	226	...	1092 ...	1092 ...	273.0 ...	104.7	...	...	...
21.	233	...	1092 ...	1092 ...	273.0 ...	111.3	...	...	...
22.	240	...	1092 ...	1092 ...	273.0 ...	113.8	...	...	...
23.	247	...	1092 ...	1092 ...	273.0 ...	118.0	...	...	...
24.	254	...	1092 ...	1092 ...	273.0 ...	124.0	...	...	...
25.	261	...	1092 ...	1092 ...	273.0 ...	125.0	...	...	...
26.	268	...	1092 ...	1092 ...	273.0 ...	130.1	...	...	...
27.	275	...	1092 ...	1092 ...	273.0 ...	132.5	...	...	...
28.	282	...	1092 ...	1092 ...	273.0 ...	132.6	...	...	...
29.	289	...	1092 ...	1092 ...	273.0 ...	135.8	...	...	...
30.	296	...	1092 ...	1092 ...	273.0 ...	137.2	...	...	...
31.	303	...	468 ...	468 ...	273.0 ...	143.2	...	...	...

Special feeding begun May 15, '05. Observations begun May 20, '05. 1 day before the end of 5th week.

Middle of 8th week.

Animal killed Dec. 20, 1905.



P.M.—FOURTH STAGE, 32ND WEEK, 303RD DAY.  
(Pig 1650).

With the exception of a small parasitic cyst in the liver, the only lesions found were those due to the inoculation of both hind legs with tubercle bacilli.

The arrangement of the inguinal and pelvic lymphatics must have been abnormal, for although there was a characteristic local lesion on the left side, the left internal superficial inguinal lymphatic gland was smaller than normal, and the same was true of the left sacro-lumbar glands.

On the other hand, the right internal superficial inguinal gland and the sacro-lumbar were more than twice the size of the same glands in other pigs. Apart from this abnormality, the changes observed in this pig were very similar to those observed in the other pigs, with that difference that the disease had spread further; but pigs 1648 and 1650 were kept more than 100 days longer after inoculation than any of the pigs of the second series, and as much as 120 days and 140 days longer than the pigs of the first series. Under these conditions one might have expected a very considerable extension of the disease in these two last pigs. That extension had taken place

## 58 INFLUENCE OF COD-LIVER OIL

was shown by the fact that the bronchial and sub-maxillary glands had become invaded.

It was, however, noticeable that although very large, the inguinal and sacro-lumbar glands were surrounded by a thick capsule of fibrous tissue, and were partly calcified. This, taken in conjunction with the fact that these animals had not been affected in their growth like the others, seems to indicate that the resistance of these pigs to tuberculous invasion had been greater than that of the others. The number of the tubercle bacilli in the inguinal glands was so small that in some sections they could not be found.

### GRAPHIC REPRESENTATION OF RESULTS.

The observations recorded in the foregoing tables are made clearer by the series of curves given in the chart prepared by Prof. Delépine, which shows at a glance the weight of each pig during the successive weeks of the experiments and the time when the oil was administered for the first time, as well as the date of each inoculation or feeding experiment. The curves given in the diagram are not corrected so as to show the rate of increase in relation to a uniform initial weight; they, however, give an absolutely correct representation of the facts observed. No curve showing the normal rate of increase of weight of pigs

during the successive weeks of the first year of life was available. It may, however, be assumed that as the pigs grew older the rate of increase was gradually lessening, and this diminution was sufficient to modify somewhat the shape of the curves within the time limits of the experiments. The steady and regular increase in weight of certain pigs is shown by an almost straight line. Any decrease in rate of growth is indicated by the line becoming more horizontal, and any loss is indicated by the line returning to a level lower than that it had reached. The curves are so arranged as to make easy a comparison of the state of the various pigs in each of the three first stages of the experiment.

#### INTERPRETATION OF THE RESULTS OF THE EXPERIMENTS.

The results will be best understood if the observations made during each stage are considered seriatim.

#### OBSERVATIONS DURING THE 1ST STAGE.

The figures recorded in the first stage show that all the pigs were gaining in weight during the period of preliminary observation. Pigs 1503, 1504, which were 45 days old, and pigs 1500, 1501, which were 59 days, at the beginning of the

## 60 INFLUENCE OF COD-LIVER OIL

observations, increased daily on an average at the rate of more than 2 per cent. of their body weight at the beginning of the period.

Pigs 1644 to 1650 inclusive, which were 93 days old, increased more slowly in weight, the average rate being 0.70 per cent. for the seven pigs. This is to be accounted for partly by their being older and partly because their food was entirely vegetable (the younger pigs had a considerable amount of milk).

Pig 1648, which showed the lowest rate of increase (0.29 per cent.), was used to test Scott's Emulsion in conjunction with pigs showing a more normal rate of increase.

It was, however, found afterwards that some of the pigs, which indicated a low rate of increase during the preliminary period, increased proportionately more rapidly than some of the pigs which at first increased more rapidly in weight.

It may be well, however, to indicate here how the pigs were grouped for purposes of experiment in order to show how an attempt was made to compensate as far as possible the effects of different rates of increase.

TABLE XII.

## Preliminary Stage. Grouping of Animals for Experiment.

Nature of Experiment.	No. of Pig.	Daily Increase % of Weight at the beginning of the period of 14 days	Average rate of increase in each group per diem.	Experiments in second stage.
1st set. Younger pigs, milk given.				
A. No oil administered.	... 1500 ...	2.2	} 2.05	Control, no oil.
	... 1503 ...	1.9		
B. „	... 1501 ...	2.1	} 2.10	Cod liver oil
	... 1504 ...	2.1		
2nd set. Older pigs, no milk given.				
C. No oil administered.	... 1644 ...	0.53	} 0.63	Cod liver oil
	... 1645 ...	0.73		
D. „	... 1646 ...	0.88	} 0.71	Scott's Emulsion
	... 1647 ...	0.80		
	... 1648 ...	0.29		
	... 1649 ...	0.75		
	... 1650 ...	0.86		

It will be noticed that the four animals used for testing the Cod-liver Oil were distributed among the two sets so as to allow of comparisons being possible between the first and second sets of experiments.

## 62 INFLUENCE OF COD-LIVER OIL

### OBSERVATIONS DURING THE 2ND STAGE.—EFFECTS OF ADMINISTRATION OF COD-LIVER OIL AND EMULSION UPON THE NUTRITION OF NON-TUBERCULOUS PIGS.

In this stage we have to consider first the effects observed during the fortnight following the period of preliminary observations. During that fortnight none of the 11 pigs under observation were affected with tuberculosis, and therefore during that period the effects of ordinary feeding, with or without the addition of Cod-liver Oil or Cod-liver Oil Emulsion were observed in the whole series.

TABLE XIII.

Effects of Cod Liver Oil and Cod Liver Oil Emulsion. 1st period of 14 days. 2nd stage of experiment.

Nature of Experiment.				No. of Pig.	Daily Increase per cent. each Pig.		Average.
1st Set. Younger pigs taking milk.							
A.	Control, no oil given	...	...	1500	...	2·	} 2·25
				1503	...	2·5	
B.	Cod Liver Oil	...	...	1501	...	2·08	} 2·39
				1504	...	2·70	
2nd Set. Older Pigs, no milk given.							
C.	Cod Liver Oil	...	...	1644	...	0·90	} 0·87
				1645	...	0·85	
D.	Emulsion	...	...	1646	...	0·80	} 0·98
				1647	...	1·0	
				1648	...	0·80	
				1649	...	1·20	
				1650	...	1·10	



In the case of five of the animals no further observations were made with regard to the action of oil.

In the case of the remaining six pigs, the second stage of the experiment was continued for 14 days longer, with the results shown in the following table:—

TABLE XIV.

Effect of Cod Liver Oil and Cod Liver Oil Emulsion. Second period of 14 days. (Second stage of experiment.

Nature of Experiment.			No. of Pig.	Daily increase % each Pig.			Average.
1st set.	Younger pigs, taking milk—						
A.	Control, no oil given	...	1500	...	2.08	}	1.89
			1503	...	1.7		
B.	Cod liver oil	...	1501	...	1.07	}	1.53
			1504	...	2.0		
2nd set.	Older animals, taking no milk—						
C.	Cod liver oil	...	1645	...	0.50	...	0.50
D.	Emulsion	...	1646	...	0.96	...	0.96

Pig 1501 showed for a time an unaccountable dislike for Cod-liver Oil; perhaps the dose was too large; this may have modified the results during this period of the experiment, but even if only the animal thriving best in each group is taken for comparison, the superiority shown by plain Cod-liver Oil during the first fortnight was not

## 64 INFLUENCE OF COD-LIVER OIL

obvious during the second fortnight. Scott's Emulsion remained at the head.

At the end of this second period of 14 days only two pigs (1645 and 1646) were uninfected; these were kept under observation for 15 weeks longer. So that when they were killed they had taken two doses of oil or emulsion daily for 141 days; the total increase in weight observed varied according to the substance given, as shown in the Table XV.

TABLE XV.

Effect of the addition of Cod Liver Oil and Cod Liver Oil Emulsion to the vegetable food of 2 pigs during a period of over  $3\frac{1}{2}$  months.

Substance given.	Pig No.	Weight at the beginning.	Weight at the end.	Total gain.	Gain % of body weight at the beginning.
C. Cod Liver Oil ...	1645 ...	20	... 46·3	... 26·3	... 131 %
D. Emulsion...	1646 ...	35·8	... 92·	... 56·2	... 156 %

OBSERVATIONS DURING THE 3RD STAGE.—EFFECT OF  
THE ADMINISTRATION OF COD-LIVER OIL  
AND COD-LIVER OIL EMULSION UPON THE  
NUTRITION OF TUBERCULOUS PIGS.

Amongst the inoculated animals those taking Cod-liver Oil Emulsion increased much more rapidly in weight than those taking Cod-liver Oil.

The plan of the experiments during the third stage has already been explained at p.27, where it has been shown that the nine tuberculous pigs had to be grouped as follows:—

I. Pigs 1500 and 1501 infected by ingestion of bovine tuberculous products at the end of the ninth week.

II. Pigs 1503 and 1504 infected by inoculation of human tubercle bacilli at the end of the sixth week, and of bovine tuberculosis products at the end of the ninth week.

III. Pigs 1644, 1647, 1648, 1649, 1650 infected by inoculation of human tubercle bacilli during the fifth week, and of tuberculous products during the eighth week.

The observations made may be summarised as follows:—

## 66 INFLUENCE OF COD-LIVER OIL

1—PIGS INFECTED BY INGESTION OF BOVINE TUBERCULOUS PRODUCTS. Young Pigs fed on meal and milk.

For about three or four days the tuberculous meal had apparently no effect; then the rate of growth appeared to be checked, and the increase in weight gradually diminished in a more or less regular fashion. This is shown in the Table XVI.

TABLE XVI.

Showing Gain or Loss of weight during the 6 weeks previous to, and the 6 weeks following infection.

Substance given.	Pig No.	Before Infection.			After Infection.		
		Weight during 4th week.	Weight during 10th week.	Gain + in 6 weeks.	Gain %	Weight during 10th week.	Gain or loss - in 6 weeks.
A. No Oil Given	... 1500 ...	38·3	61·0	... +22·7	... 59·0	61·0	... -2·5
B. Cod-liver Oil	... 1501 ...	37·3	50·5	... +13·2	... 36·0	50·5	... +0·7
						51·2	... +1·3

Gain or loss %



These records show that the pig which was taking no oil suffered more severely from the tuberculous infection than the pig taking the Cod-liver Oil.

2—PIGS INFECTED BY INOCULATION OF HUMAN OR BOVINE TUBERCULOUS PRODUCTS. Young Pigs fed on meal and milk.

Very little effect was noticed after the inoculation of the pigs with a pure culture of human tubercle bacilli at the end of the sixth week, and it was only about ten days after subcutaneous inoculation of the same pigs three weeks later with bovine tuberculous products that two of the pigs (1503 and 1504) showed a marked evidence of being affected in their general health.





TABLE XVII.

Showing Gain or Loss of weight of Tuberculous Pigs taking no oil, or cod liver oil.

Substance given.	Pig No.	Before Inoculation.			After 1st Inoculation.			After 2nd Inoculation.			- Loss or + Gain in 3 weeks.	%		
		Weight during 4th week.	Weight during 7th week.	Gain in 3 weeks.	Weight during 10th week.	Gain in 3 weeks.	Weight during 13th weeks.	Gain in 3 weeks	Weight during 16th week.					
A., No oil ...	1503 ...	40.4 ...	53.0 ...	12.6 ...	31 ...	62.5 ...	9.5 ...	17 ...	68 ...	5.5 ...	8.8 ...	67.2 ...	- 0.8 ...	- 1.1
B., Cod-liver oil ...	1504 ...	35.1 ...	47.9 ...	12.8 ...	36 ...	58.0 ..	10.1	21	61 ...	3.0	5.1	61.2 ...	+ 0.2 ...	+ 0.3



This table shows that during the first two periods of three weeks and during the last the pigs taking Cod-liver Oil were doing distinctly better than the pigs taking no oil; during the third period of three weeks the pigs taking Cod-liver Oil did not gain weight so rapidly as the one taking no oil; but pig 1504 taking Cod-liver Oil gained weight up to the end.

3—PIGS INFECTED BY INOCULATION OF HUMAN AND BOVINE TUBERCULOUS PRODUCTS. Pigs older than in 1 and 2 and taking only vegetable food.

Very little effect was noticed after the first inoculation with human tubercle bacilli; pig 1644 taking Cod-liver Oil, lost some weight during the third week after the first inoculation. None of the pigs taking emulsion showed any signs of being affected.

For four weeks after the second inoculation no further definite loss of weight was observed. Towards the end of the fourth week the rate of increase was reduced in 1644 (Cod-liver Oil) and 1647 (emulsion). The other three pigs taking emulsion showed no evidence of being affected by the two inoculations.

## 74 INFLUENCE OF COD-LIVER OIL

After the fourth week the pig taking Cod-liver Oil (1644) lost weight for two weeks, after which it appeared to recover slowly. Pig 1647 taking emulsion, recovered rapidly from the arrest observed during the fourth week, and increased rapidly in weight till it was killed in the 16th week.

Pig 1649 (emulsion) increased steadily and rapidly in weight till the end of the 16th week. The inoeulations seemed to have no effect upon its rate of growth.

The same steady and rapid increase was observed in pigs 1648 and 1650, also taking emulsion till the 26th week of the experiments, after which pig 1648 began to lose weight. Pig 1650 continued, however, to gain steadily and rapidly till the end of the 31st week, when it was killed.

For purposes of comparison the records of weight are divided in Table XVIII. into the following periods:—Three weeks before the first inoeulation, three weeks after the first inoculation, eight weeks after the second inoeulation, and in the two cases remaining the last 15 weeks were divided into two periods of eight and seven weeks respectively.

TABLE XVIII.

Showing Gain or Loss of Weight of Tuberculous Pigs taking Cod Liver Oil or  
Cod Liver Oil Emulsion.

Substance given.	Pig No.	Before 1st Inoculation.			After 1st Inoculation.			After 2nd Inoculation.			Weight during the 31st week.	Gain or loss in 7 weeks. %			
		Weight during 2nd week.	Weight during 5th week.	Gain in 3 weeks. %	Weight during 8th week.	Gain in 3 weeks. %	Weight during 16th week.	Gain in 8 weeks. %	Weight during 24th week.	Gain in 8 weeks. %					
C. Cod liver oil	1644...	25·5...	29·5...	4	15	.....	32·2...	2·7	9	.....	35·5...	3·3	10...	—	—
D. Scott's Emulsion	1647...	37·3	44·1...	6·8	18	.....	55·6...	11·5	26	.....	7·2...	16·4	29...	—	—
"	1649.	39·7...	47·0...	7·3	18	.....	58·6...	11·6	24	.....	83·5...	24·9	42...	—	—
"	1648...	30·3...	35·7...	5·4	17	.....	45·8...	10·1	28	.....	71·8...	26·0	56...	28	89·5 ... -2·8 -3
"	1650...	41·0...	49·6...	8·7	21	.....	64·5...	14·9	30	.....	93·5...	29·0	44...	124	32 ..143·2 ... +19·2 +15



4th STAGE—LESIONS FOUND IN TUBERCULOUS PIGS  
TAKING COD-LIVER OIL OR COD-LIVER OIL  
EMULSION.

Evidences of tuberculosis were looked for with special care in every case in the following groups of lymphatic ganglia:—Inguinal, iliac, sacro-lumbar, lumbar, retro-hepatic, bronchial, sub-maxillary; and in the following organs:—Liver, spleen, lungs. Exact measurements were taken of corresponding glands in each case, the amount of enlargement, of necrosis, caseation, calcification and fibrosis noted. Suspicious lesions were examined microscopically. Lesions of a lymphatic gland and of a lung which had the characters of tuberculous lesions, but in which tubercle bacilli could not be found, were tested by inoculation, and found to be tuberculous.

CONTROLS.

As was expected, the two pigs (1645 and 1646) which had not been fed or inoculated with tuberculous products showed no evidence of tuberculosis in any of the lymphatic ganglia examined. These animals were 237 days old when they were killed, and had been kept under observation under the same conditions as the other pigs for 21 weeks.

## 78 INFLUENCE OF COD-LIVER OIL

### ANIMALS INFECTED THROUGH THE ALIMENTARY CANAL.

All the other animals were found tuberculous at the time of death. In those which had been fed one day only with tuberculous products 46 days before death, and which were 164 days old at the time they were killed, the mesenteric glands were found caseous, and contained tubercle bacilli. The retro-hepatic gland was also enlarged and more or less caseated. No clear tuberculous lesions of the liver or spleen could be recognised by the naked eye.

The lymphatic glands, other than those mentioned, were normal. Apart therefore from the *general state of the animals at the time of death*, there was nothing to indicate which animal had been least affected by the disease.

### ANIMALS INFECTED BY INOCULATION.

#### A.—1ST SET.

Of the animals inoculated, two of the first set, viz., 1503, 1504, were killed 46 days after being infected with bovine tuberculosis, and 67 after infection with human tuberculosis; they were 150 days old when they died.

The lymphatic glands corresponding to the left leg, which had been inoculated with human



tubercle bacilli, were all enlarged, caseous and contained tubercle bacilli; there was no material difference between the two animals.

The glands corresponding to the right leg, which had been inoculated later with bovine tuberculous material, were very little affected. The glands of the animal taking no oil were possibly a little more enlarged than those of the pig taking Cod-liver Oil, but the difference was not of such a nature as to convey information of a definite character.

#### B.—2ND SET.

Pig 1644 (Cod-liver Oil) was killed 81 days after the left leg had been infected with human tuberculosis, and 63 days after the right leg had been inoculated with bovine tuberculous products; pigs 1647 and 1649, which were taking emulsion, were killed 82 days after the left leg had been inoculated and 64 days after the right had. All these pigs had therefore been kept after inoculation for the same length of time (but for one day), and they were all either 201 or 202 days old when they were killed. The lesions observed in all these pigs were similar in character; there was a local tuberculous lesion at the seat of inoculation in both legs. Tubercle bacilli were more abundant on the left than on the right side. The same

## 80 INFLUENCE OF COD-LIVER OIL

characteristic features were observable in the lymphatic glands on the right and on the left sides respectively. Here again *the only thing which indicated a marked difference between the four pigs was the state of general nutrition.* Pig 1648 was killed 185 days after inoculation of the left leg and 167 days after inoculation of the right; it was 305 days old at the time of death. Pig 1650 was killed 187 days after inoculation of the left leg and 169 days after inoculation of the right; it was 307 days old at the time of death; both these pigs were taking emulsion. They were kept longer than the other pigs in order to ascertain whether the lesions observed at an earlier date would show evidences of healing. To a certain extent they did. The left local lesions still contained typical tubercle bacilli, but the lesion was surrounded by a dense layer of fibrous tissue limiting it sharply. The bovine lesion in the right leg was of considerable size, very fibrous, partly calcified, but ill-defined, and no tubercle bacilli were found on microscopic examination of some preparations and very few in others. The same was true of the corresponding lymphatic glands, which were of considerable size. On inoculating guinea-pigs with a small portion of one of these lymphatic glands it was found that it was still capable of producing tuberculosis, so that tubercle

bacilli were still present and active, though difficult to demonstrate microscopically.

Therefore, although there were indications of a tendency to recovery, it was clear that the disease was not entirely arrested, and it would not be safe to assume that if the animals had been allowed to live complete recovery would have taken place. On the other hand, the general health of these pigs appeared to have suffered very little in the case of one pig, and practically not at all in the case of the other, an effect which was very favourable to ultimate recovery.

These experiments demonstrate that—

- (1) Pigs taking the same diet gain weight more rapidly, and consequently are better nourished when a suitable dose of Cod-liver Oil is added to the diet.
- (2) Pigs taking vegetable diet to which the Emulsion had been added in doses containing the same amount of oil as the foregoing showed a more rapid growth than animals fed
  - (a) on vegetable diet,
  - (b) on vegetable diet with Cod-liver Oil.

## 82 INFLUENCE OF COD-LIVER OIL

- (3) The efficacy of Cod-liver Oil is enhanced in a marked degree when it is administered in the form of an Emulsion such as was used in the experiments.
- (4) The foregoing is true both in tuberculous and non-tuberculous pigs.
- (5) Pigs affected with tuberculosis continued to increase rapidly in weight, and appeared quite comfortable and happy for a long period when the Cod-liver Oil Emulsion was added to the usual diet. Their tuberculous lesions showed signs of possible recovery, tuberculous glands became fibrous and calcified, and the tubercle bacilli more difficult to demonstrate.

These evidences of possible recovery bring one to a clinical stage of much importance, in fact link the experimental to the clinical investigations of tubercular disease.

These experiments point to the same conclusions as the investigations made by the writer in 1903, when Cod-liver Oil was shown to be not only an easily assimilated fatty food, but a drug with the therapeutical effect of increasing the assimilation of other fats in the food and diminishing body

waste, as demonstrated by the lessened elimination of nitrogen. He found that these properties were most evident when the oil was administered in the form of the Emulsion used in the present series of experiments. (Proceedings British Medical Association, "British Medical Journal," Oct. 18, 1902.)

The experiments previously detailed show that the nutrition of tuberculous animals was improved by the addition of Cod-liver Oil to their food. This improvement was most marked when Scott's Emulsion of Cod-liver Oil, which is a pharmaceutical preparation of defined composition, was given instead of the plain Oil. Changes indicative of progress towards recovery were also observed in the tuberculous glands of animals taking Scott's Emulsion. Among these changes the following may be specially mentioned:—

- (a) Considerable production of fibrous tissue in connection with the stroma and capsule of the glands.
- (b), Well marked evidence of calcification.
- (c) Reduction in the number of tubercle bacilli.





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